Some Morphological Observations of Tyloses

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加藤弘之*・貴島恒夫*：チロースの形態について

In hardwoods, vessels play a main role of liquid penetration into them, and the vessel penetration is controlled first of all by the development of tyloses in the vessels.

If the quantitative proportion of tyloses to the vessel lumen might be given, it would be possible to estimate the degree of liquid penetrability of wood to a certain extent. Such a quantitative estimation, however, was found to be difficult beyond the authors expectation.

During the above trial for the quantitative estimation, some morphological observations of tyloses were carried on, and the results obtained will be reported in this paper. And further, it is generally known that tyloses are usually formed in a process of heartwood formation (CHATTAWAY, 1949 ; TRENDELENBURG, 1955 ; DADSWELL and HILLIS, 1962), accordingly the observations were carried out in connection with heartwood formation.

Materials and Methods

The following six species of hardwoods, of which the development of tyloses seems to be comparatively conspicuous, were chosen as the materials.

ONIGURUMI : Japanese walnut (*Juglance sieboldiana* MAXIM.), domestic.
HOWAITO-OKU : white oak (*Quercus alba* LINN.), from North America.
SHIRAKASHI : oak sp. (*Quercus myrsinaefolia* BL.), domestic.
KURI : Japanese chestnut (*Castanea crenata* SIEB, et ZUCC.), domestic.
NISEAKASHIA : black locust (*Robinia pseudoacacia* LINN.), domestic.
AKARAWAN : red lauan (*Shorea negrosensis* FOXW.), from South-east Asia.

A. Light Microscopic Observation

For this observation the wood blocks were softened in autoclave (120°C, 3kg/cm^2, 60-90 min.), and were sectioned by a JUNG-type sliding microtome with attention to avoid removal or breakdown of tyloses. According to a trial in advance, sections adequate to the purpose were 15-25μ thick and 5×10 mm in size. They were made into temporary preparations mounted with glycerine jelly.

For histochemical observation, the following colour reactions and stainings (Table) were applied, and for the observation of physical properties of tylosis wall the polar-

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izing microscope was used.

Table Tests for color reactions and stainings

	Reagent for colour reaction	Dyestuff
Cellulose	Iodine-potassium iodide solution Zinc chloride-iodine solution	Methylene blue Safranin
Lignin	Phloroglucinol hydrochloric acid	
Pectic substance		Ruthenium red
Cork		Sudan IV
Lipid		

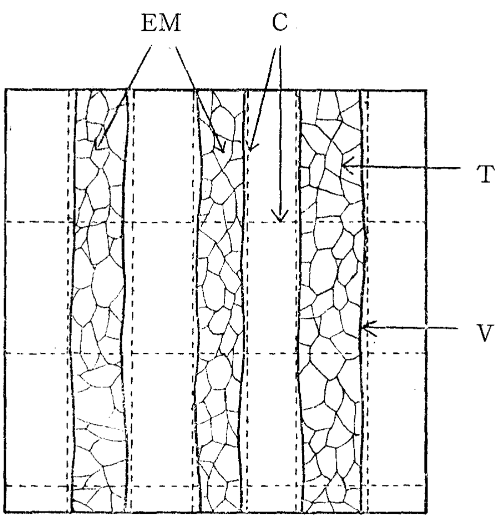

Fig. Replica film
EM : Unit replica for electron microscopic observation
C : Cutting line
T : Tylosis
V : Vessel

B. Electron Microscopic Observation

For this observation, heartwoods of white oak, chestnut and black locust were mainly used, and the replica method (filmy replica mould ; acetylcellulose method) was applied to their longitudinal surfaces (radial or tangential). As the specimens for electron microscope, a part of replica films moulded by the surface of vessels full of tyloses was put on a sheetmesh (Fig.). The electron microscope used was type JEM-T6S (60KV).

Observation Results and Discussion

A. Shape of Tyloses

SHIRAKASHI (oak sp.)

In SHIRAKASHI, tylosis formation increases gradually from sapwood to heartwood and every successive stages of tylosis development are well observed. Initial bud tyloses (Photo 1) can be seen in earlywood vessels of the sapwood. Subsequent stages of the development of tyloses are illustrated in Photo 2. It is shown in Photos 1 and 2 and more obviously in Photo 3 that every tylosis arises from only a ray parenchyma cell adjacent to a vessel, where no thickening of the vessel wall exists.

This partial lack of thickening of the vessel wall is characteristic of Shirakashi which is the only species among the materials in the present investigation.

HOWAITO-OKU (white oak)

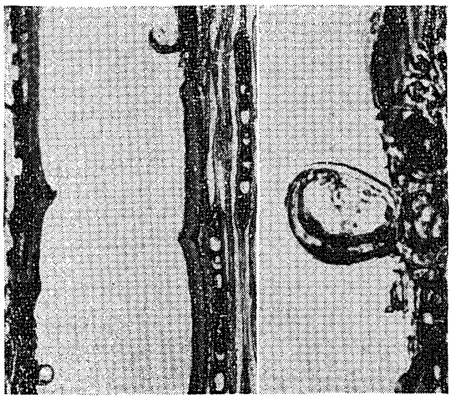

Photo 1. Bud tyloses in early wood. SHIRAKASHI (oak sp.), sapwood, (*t*), ×130 & ×400.

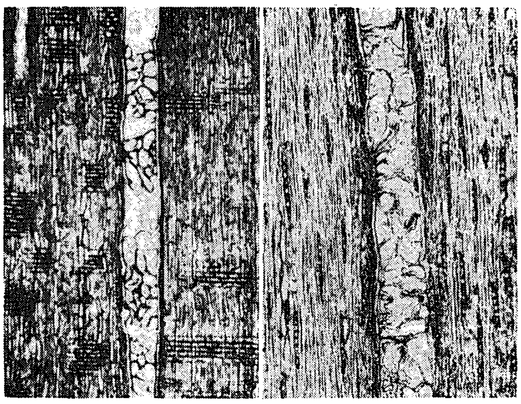

Photo 2. Development stages of tyloses in late wood vessels, SHIRAKASHI, heartwood, (*r*) (*t*), ×40.

Photo 3. Bud tyloses arising from ray parenchyma cells adjacent to a vessel, where no thickening of the vessel wall exists. SHIRAKASHI, sapwood, (*t*), ×130.

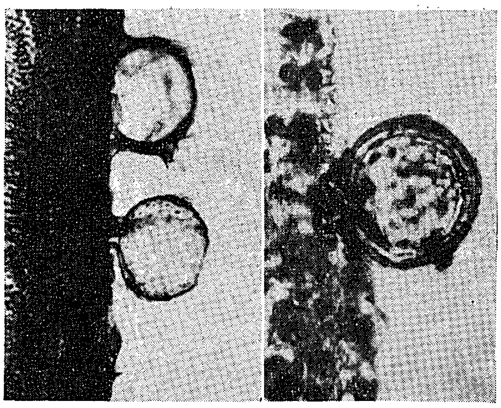

Photo 4. Bud tyloses. White oak, sapwood, (*t*), × 95 & ×220.

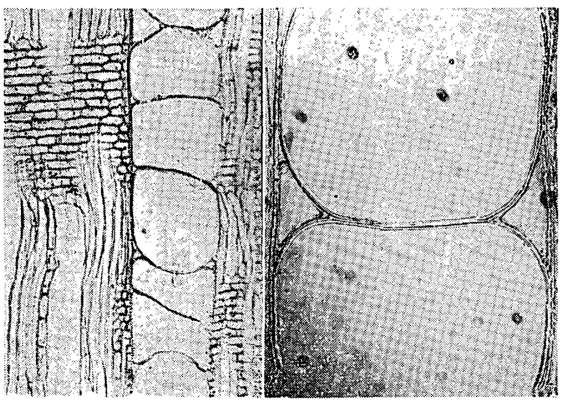

Photo 5. Tyloses blocking the vessel lumen in a row likly to the vessel segments. White oak, sapwood, (*r*), ×110 & ×210.

In white oak numerous tyloses occur even in sapwood, and bud tylosis shows nearly a globular form (Photo 4). In most cases, tyloses in sapwood arranging in a longitudinal row (Photo 5) block the lumen of vessel so closely that each tylosis appears to be likely a vessel segment.

NISEAKASHIA (black locust)

In black locust the plentiful development of tyloses is observed in its final stage (Photo 6). Abundant tyloses block the lumen of vessel so closely that every

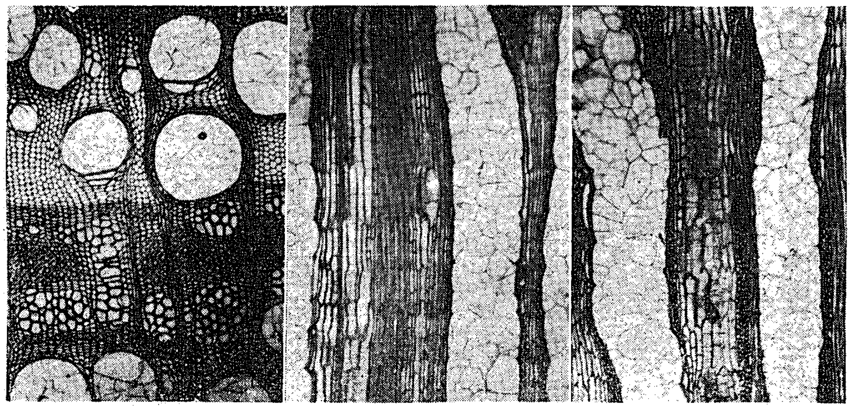

Photo 6. Abundant development of tyloses in vessels. Black locust, sapwood, (*x*) (*r*) (*t*), ×30.

tylosis shows nearly similar polyhedral form in three dimensional sections. Besides, such an appearence of tylosis is generally observed both in sapwood and heartwood, and initial bud tyloses are hardly found in the present investigation, therefore, it is supposed that they will nearly all be in the cambial zone.

B. Structure of Tylosis Walls

Photo 7 shows a tylosis in the sapwood of white oak. In its surface the fibrillar orientation can be seen but is not always well-regulated. Since the transverse sections of tylosis walls appear usually bright, showing the double refraction between crossed nicols under the polarizing microscope (Photo 8), microfibrils in tylosis wall orient parallel to the wall surface and are interwoven over the surface.

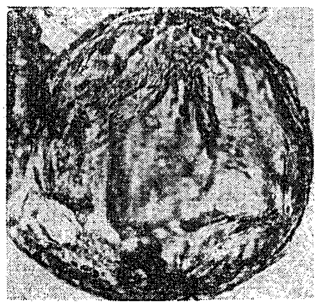

Photo 7. Fibrillar structure in the surface of a bud tylosis. White oak, sapwood, (*t*), ×210.

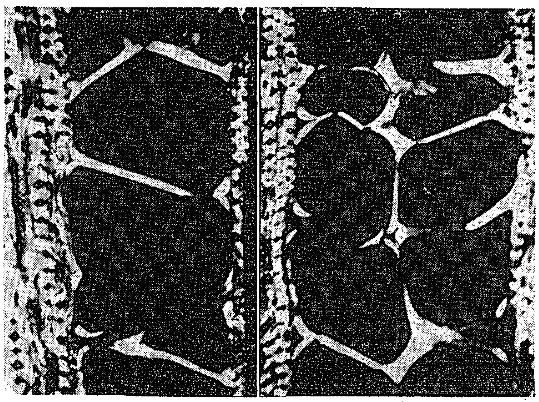

Photo 8. Transverse sections of tylosis walls showing the double refraction under the polarized light. White oak, sapwood & heartwood, (*t*), ×240.

In Photos 9 and 4 many minute spots like pits are found in the surfaces of tylosis wall of white oak. Similar spots are also found in black locust (Photo 10) but it is not distinctive from these micrographs whether such a spot is a true pit or a mere indenture of the wall.

In microchemical observation of color reactions on the tylosis walls of white oak,

Photo 9. Pit-like structure on a tylosis wall. White oak, sapwood, (*t*), $\times 300$.

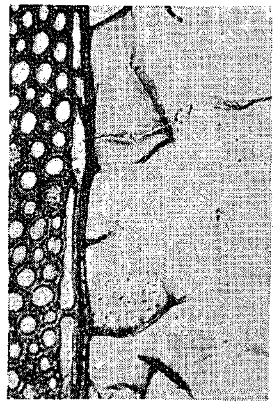

Photo 10. Tyloses arising from wood parenchyma cells and having the pit-like structure. Black locust, sapwood, (*t*), $\times 190$.

the presence of cellulose in them can be confirmed by the positive reaction with iodine-potassium iodide or zinc chloride-iodine solution. On the other hand the lignification of them is also recognized by the scarlet colour reaction with phloroglucinol-hydrochloric acid or by the staining with safranin or methylen blue. Besides, from the staining with ruthenium red and sudan IV, the presence of pectic substance, lipid, or suberisation is found although not so evident as the colour reactions on cellulose or lignin.

Electron microscopic observations of the tylosis walls are not yet sufficient. Among a few instances, Photo 11 shows a structure found in a replica of tylosis wall surface of white oak heartwood. Many wrinkles and small prominences on the wall surface are considered to be resulted by the encrustation of lignin. Photo 12 shows the structure found in a replica on the tylosis wall surface of heartwood in Japanese chestnut, and double kinds, small and large ones, of prominent warts are remarkable.

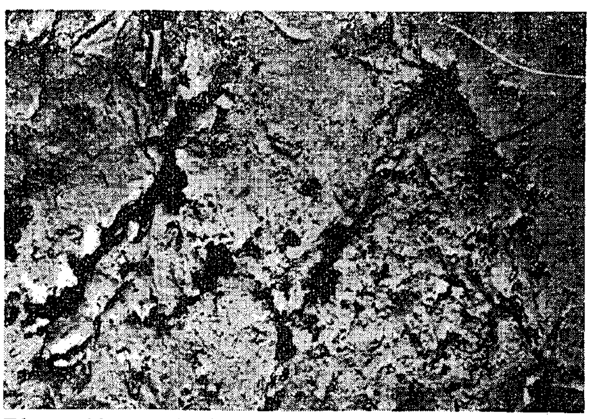

Photo 11. Tylosis wall surface showing many wrinkles and minute prominences. White oak, heartwood, e. m. replica, $\times 1400$.

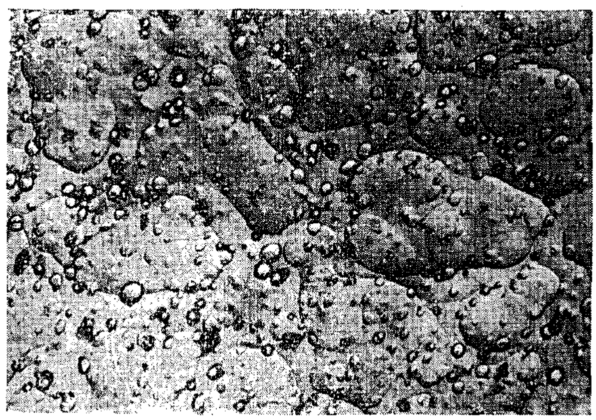

Photo 12. Tylosis wall surface. Japanese chestnut, heartwood, e. m. replica, $\times 6000$.

Conclusion

1. In black locust and white oak, tyloses are abundantly present throughout their

sapwood, up to the outer most rings of it, and heartwood. These two species are the typical woods showing plentiful development of tyloses in vessels.

2. Tyloses in SHIRAKASHI (oak sp.) show quite various shapes and every successive stages of their development obviously.

3. In tylosis formation in SHIRAKASHI, it is remarkable that its tyloses arise from ray parenchyma cells adjacent to vessels, and where no thickening of the vessel wall exists.

4. Tyloses arising from longitudinal wood parenchyma cells are found only in black locust as to the present investigation.

5. Tylosis walls in white oak show the secondary thickening and the lignification to a certain extent. Besides, the structure of fibrillar orientation is observed in the tylosis wall.

6. On the surfaces of tylosis walls in Japanese chestnut, there are double kinds, small and large ones, of numerous prominent warts.

摘　　要

チロースの発達の著しい内外産広葉樹材6種についてその形態を光学顕微鏡的に観察し，さらにチロース膜の表面構造を電子顕微鏡的に観察して，チロースの形成発達の推定に資し，あわせて顕微化学的，偏光顕微鏡的観察を行なつてチロース膜の性質を知る一助とした。その結果を要約すれば，

1. ニセアカシアとホワイトオークはともに辺材最外輪にすでにチロースが見られ，辺・心材を通じて密に存在し，チロース発達の最も著しい樹種である。

2. シラカシのチロースは不規則な形を示し，その発達段階が明らかに観察される。

3. 同じくシラカシのチロース形成上注目すべきは，それが由来する放射柔組織が道管と隣接しいる部分に道管の肥厚が見られないことである。

4. この観察の範囲で木部柔細胞に由来するチロースを認めたのはニセアカシアのみであつた。

5. ホワイトオークのチロース膜は2次的肥厚を示し，かなり木化しているのみならず，フィブリルの配向が見られる。

6. クリのチロース膜の表面には大小2種のいぼが重複的に存在し，非常に特徴的である。

Literature Cited

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